What is claimed is:

1. A method of estimating one or more properties of a multi-component fluid contained in a physical system containing two or more phases, comprising the steps of:

(a) equating the physical system in at least one dimension to a multiplicity of cells;

(b) for each cell, characterizing the multi-component fluid in the cell using a property of a first set of components and representing the characterization by a first vector;

(c) converting the first vector to a second vector using a transformation matrix, the transformatin matrix being indicative of the distribution of the first set of components and the second vector being representative of a property of a second set of components greater in number than the first set of components;

(d) using the second vector to determine the number and properties of phases present in each cell;

(e) determining the elements of a first matrix that expresses distribution of the second vectors among the phases;

(f) determining the elements of a second matrix that expresses how the first vectors are distributed among the phases using the transformation matrix and the first matrix;

(g) determining a third matrix that expresses the composition of the phases in terms of the first vectors; and

(h) using the third matrix to perform fluid flow calculations to estimate one or more properties of the multi-component fluid.

2. A method for simulating fluid movement and phase change behavior, wherein the method comprises:

(a) determining for each of a plurality of discrete cells a vector of first domain component concentrations;

(b) transforming the first domain component vectors into vectors of second domain component concentrations;

(c) applying to the second domain component vectors, equations of state to determine second domain component distribution matrices indicative of a distribution of the second domain components among each of the phases;

(d) converting the second domain component distribution matrices to first domain component distribution matrices; and

(e) applying the first domain component distribution matrices to fluid flow equations to determine for each of the plurality of discrete cells an updated vector of first domain component concentrations.

3. The method of claim 2, wherein the converting includes multiplying the second domain component distribution matrix with a transform matrix.

4. The method of claim 2, further comprising:
displaying the concentrations of a desired component in a given cell at a given time.

5. A nonlinear process simulator which comprises:

(a) a display monitor;

(b) a processor coupled to the display monitor and configured to display time evolution of the process; and

(c) a memory configured to store software for access by the processor, wherein the software includes:

a second domain module which configures the processor to determine a distribution of second domain components among a plurality of phases, wherein the second domain component distribution is expressible in terms of a second domain component distribution matrix having elements that specify what fraction of each second domain component is found in a given phase; and

a conversion module which configures the processor to convert the second domain component distribution matrix into a first domain

component distribution matrix by multiplying the second domain component distribution matrix with a transform matrix to obtain a first domain component distribution matrix, wherein the second domain components are expressible as a product of the first domain components and the transform matrix.

6. The simulator of claim 5 wherein the software further includes:

(a) a first domain module which configures the processor to determine for each of a plurality of discrete cells a vector of first domain component concentrations;

(b) a transform module which configures the processor to transform the first domain component concentration vectors into second domain component concentration vectors, wherein the second domain module operates on the second domain component concentration vectors to determine the second domain component distribution matrix.

7. The simulator of claim 6 wherein the software further includes a display module that configures the processor to display concentrations of a desired component in a given cell at a given time.

8. The simulator of claim 6, wherein the first domain module performs simulation of fluid flow, and the second domain module performs simulation of fluid phase behavior.

9. The simulator of claim 8, wherein the software configures the processor to simulate development of petroleum reservoirs by repetition of actions that include simulating fluid flow in the first domain, transforming first domain component concentrations into second domain component concentrations, simulating fluid phase behavior in the second domain, and converting the second domain component distribution matrix into the first domain component distribution matrix.

10. The simulator of claim 8, wherein the software configures the processor to simulate movement of petroleum in petroleum reservoirs by repetition of actions that include simulating fluid flow in the first domain, transforming first domain component concentrations into second domain component concentrations, simulating phase behavior in the second domain, and converting the second domain component distribution matrix into the first domain component distribution matrix.

11. An information carrier medium configured to provide a processor with a program, wherein when the processor executes the program the processor is configured to:

(a) determine a distribution of second domain components among a plurality of phases, wherein the distribution is expressible as a second domain component distribution matrix having elements that specify what fraction of each second domain component has a given phase; and

(b) convert the distribution of second domain components among the phases to a distribution of first domain components among the phases, wherein the second domain components are expressible as a product of the first domain components and a transform matrix, and wherein the conversion of the distribution includes multiplying the second domain component distribution matrix with the transform matrix to obtain a first domain component distribution matrix.

12. The carrier medium of claim 11, wherein the carrier medium is a computer-readable information storage medium.

13. The carrier medium of claim 11, wherein the carrier medium is an information transmission medium.

14. The carrier medium of claim 11, wherein the program further configures the processor to:

(a) evaluate equations expressed in terms of a first domain to determine first domain component values;

(b) transform the first domain component values into second domain component values; and

(c) evaluate equations expressed in terms of a second domain to determine the distribution of second domain components.

15. The carrier medium of claim 14, wherein the first domain equations include fluid flow continuity equations. and wherein the second domain equations include phase equilibrium and flash equations.

16. The carrier medium of claim 15, wherein the program configures the processor to simulate development of petroleum reservoirs by repetition of actions that include evaluating fluid flow equations in the first domain, transforming first domain component values into second domain component values, evaluating phase equilibrium and flash equations in the second domain, and converting the second domain component distribution into the first domain component distribution.

17. The carrier medium of claim 15, wherein the program configures the processor to simulate movement of petroleum in petroleum reservoirs by repetition of actions that include evaluating fluid flow equations in the first domain, transforming first domain component values into second domain component values, evaluating phase equilibrium and flash equations in the second domain, and converting the second domain component distribution into the first domain component distribution.